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METHOD OF MOISTURE DETERMINATION OF IRON ORE LOT

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Indian Standard

METHOD OF MOISTURE DETERMINATION OF IRON ORE LOT

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Indian Standard

METHOD OF MOISTURE DETERMINATION OF IRON ORE LOT

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 11 June 1986, after the draft finalized by the Methods of Sampling Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 Moisture content has an important bearing in the final trading price of the ore. Great care is required to be taken in determining the moisture content which is essentially a simple operation. A small inaccuracy in the measurement of mass during moisture test can result in a significant discrepancy in total dry mass of the consignment. Hence, a need has been felt to formulate a comprehensive Indian Standard method for determination of moisture content of iron ore in a lot.

0.3 In preparing this standard, assistance has been taken of the following draft standard:

ISO/DIS 3087 Iron ores — Determination of moisture content of a consignment. International Organization for Standardization (ISO).

0.4 It is sometimes difficult to conduct sieving, crushing and sample division because of the sample being adhesive or sticky or excessively wet. This calls for the sample being predried before conducting these tests without trouble. This standard also prescribes procedure for determining the predried moisture content of a lot.

0.5 In reporting the result of a test or analysis, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard specifies method for determining the mean value of moisture content of a lot of iron ore.

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*Rules for rounding off numerical values (*revised*).

This method is applicable to all iron ores, natural or processed (for example, agglomerates, such as pellets and sinters). However some limonites, sulphides and ores with high combined water may give erroneous results of moisture content under conditions prescribed in this standard.

2. TERMINOLOGY

2.1 Consignment — The quantity of ore as agreed upon between the parties concerned, offered for inspection at one time.

2.2 Lot — The quantity of ore indicated to be of the same category in a consignment.

2.3 Sub-lot — The quantity of ore in each of the parts into which a lot is divided for the purpose of sampling.

2.4 Gross Sample — Sample collected from a sub-lot.

2.5 Moisture Sample — Sample drawn for determination of moisture content of a lot or sub-lot.

2.6 Test Sample — A sample ready for moisture determination which is prepared from each moisture sample following specified procedure and intended for laboratory testing.

3. GENERAL RULES

3.1 The sample for determination of moisture shall be taken in accordance with IS : 1405-1982* and IS : 9101-1979†.

3.2 The moisture sample shall, as a rule, be taken at a point immediately before or after, that is, as close as possible to the weighing point of the lot, before any change in the moisture content of the lot takes place.

3.3 The moisture sample/test sample shall be collected in a water tight container with a tight fitting lid.

3.4 Care shall be taken, during the period from sampling till the measurement stage, on the sample containers, storage conditions, transport conditions and method of sample preparation, to protect the sample from moisture change due to evaporation, rain, spillages, etc.

3.5 The sample which has been sieved in water for size determination shall not be used for determination of moisture content.

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*Methods of sampling iron ores (*second revision*).

†Methods of sampling iron ore pellets.

3.6 When the sample for moisture determination is prepared from the gross sample after it is subjected to size determination test, the preparation of test sample shall be started immediately so as not to alter moisture content. Also, moisture determination shall also be initiated immediately thereafter.

3.7 When it is difficult to conduct sieving, crushing and sample preparation in view of the sample being adhesive or excessively wet, the sample may be predried till the sample preparation can be conducted without trouble. In this case, the predried moisture shall be obtained as specified in Appendix A.

3.8 When the handling of the ore is effected during monsoon season or water is sprayed on dust emitting ores to prevent dust pollution, the moisture results will be inflated to a certain extent. In order to arrive at the original moisture content of the lot, a correction has to be applied to the moisture values. The method of moisture correction is given in Appendix B.

4. PRINCIPLE

4.1 The test sample of a prescribed mass and particle size shall be dried by heating in a dry oven at a prescribed temperature till a constant mass is obtained. From the difference of the initial and dried masses of the sample, the moisture content, as percentage by mass shall be determined.

5. SAMPLE

5.1 The test sample prepared from moisture sample according to IS : 1405-1982* or IS : 9101-1979† shall be subjected to determination of moisture content. The test sample shall preferably be (and of mass sufficient for at least five moisture determinations) of minus 10 mm size. For every gross sample, two test samples of 1 kg each shall be normally submitted for determination of moisture content, subject to the provision laid down in **8.3.**

6. APPARATUS

6.1 Drying Pan — Preferably a rectangular pan having a smooth surface free from contamination, made of material which does not react with sample and capable of accommodating at least a kilogram of test sample in a layer of thickness not greater than 20 mm.

6.2 Drying Oven — Capable of maintaining automatically the drying temperature of 105°C within ± 5°C and of accommodating sufficient number of drying pans.

---

*Methods of sampling iron ores (*second revision*).

†Methods of sampling iron ore pellets.

6.3 Weighing Device — Having adequate capacity relative to mass of the test sample. It shall have a sensitivity of 0·05% or more of the initial mass of the sample.

7. PROCEDURE

7.1 Spread the test sample in a thickness not more than 20 mm in the tared predried drying pan and determine the total mass immediately. Record the total mass, the mass of the drying pan, the initial mass of the test sample and the numerical value of 0·05% of the initial mass of the test sample.

7.2 Place the drying pan with the test sample, in the drying oven set at 105°C, and heat and maintain at this temperature for not less than 4 hours.

7.3 Then remove the drying pan with the test sample from the drying oven. After removing from the oven, the drying pan containing the sample should be weighed immediately on the balance.

7.4 Again place the drying pan with the test portion in the drying oven, heat for further 1 hour and repeat the weighing.

7.5 Repeat the above procedure, until the difference in mass between subsequent weighings becomes 0·05% or less of initial mass of the test sample.

NOTE 1 — Weighing device shall be protected from the effects of the hot material.

NOTE 2 — In case a number of moisture measurements are carried out on the same type of iron ore, the heating time of the test sample may be determined by experiments beforehand.

8. EXPRESSION OF RESULTS

8.1 The value of moisture content of each of the duplicate samples shall be calculated to three decimal places and rounded off to two decimal places in accordance with IS : 2-1960*. The moisture content shall be determined as:

$$M_1 = \frac{m_1 - m_2}{m_1} \times 100$$

where

M_i = value of moisture as percentage by mass, of each test portion corresponding to *i*th gross sample;

m_1 = initial mass, in grams, of the test sample; and

m_2 = mass, in grams, of the the test sample after drying.

---

*Rules for rounding off numerical values (*revised*).

8.2 The maximum permissible tolerance of moisture determination, when duplicate measurements have been carried out in the same laboratory, should be as follows:

Range of Average Moisture Content	*Maximum Permissible Tolerance, T (Abs %)*
3% and under	0·26
Over 3% and up to 6%	0·33
Over 6%	0·40

8.3 If the difference in moisture content between the two duplicate values does not exceed the above limit, report the average of the two values as the final moisture content of a gross sample (representing the sub-lot). If the duplicate values exceed the above limit, the moisture determination should be repeated on another set of duplicate samples. If these last two values meet the above tolerance limit, then report the average of these two values as the final moisture content of a gross sample. If the last two values of the duplicate determination still do not meet the above tolerance limit, pool all the four results of the two sets of duplicate measurements, discard the maximum and minimum values and calculate the mean value of the remaining two values as the final moisture content of the gross sample representing a sub-lot.

8.4 Final Moisture Content of the Lot — Report the weighted mean of the values of all sub-lots into which the lot has been divided, as the final moisture value of the lot, calculated to the second decimal place in the following manner:

$$M = \frac{\sum_{i=1}^{K} m_i \times M_i}{\sum_{i=1}^{K} m_i}$$

where

M = the final moisture content as a percentage by mass of the lot;

K = number of sub-lots into which the lot is divided;

m_i = mass of ith sub-lot; and

M_i = moisture, percentage by mass, of the ith gross sample (sub-lot).

9. TEST REPORT

The test report shall include the following information:

a) Reference to this standard,
b) Details of identification of sample, and
c) Final moisture content of the lot (the moisture content of all the gross samples representing the lot may be given for reference).

APPENDIX A

(*Clause* 3.7)

DETERMINATION OF MOISTURE CONTENT OF ADHESIVE OR WET IRON ORES

A-1. When it is difficult to conduct sieving, crushing and dividing due to the sample being adhesive or excessively wet, the sample may be predried until preparation can be conducted without trouble.

NOTE — If mass of the moisture sample is not large, the entire quantity of sample may be dried to conduct moisture determination according to the method specified in this standard.

In this case, the moisture content of the lot shall be obtained by using the pre-drying method to be conducted on each gross sample as indicated below:

a) Determine the initial mass of sample.

b) Spread the sample in a uniform thickness in a sufficiently large drying tray and dry it by air-drying or in a drying apparatus with a temperature not more than 105°C. The choice of the time for this stage shall not exceed a point where the sample is likely to reabsorb moisture during subsequent processing.

c) After drying, again determine the mass of the sample.

d) Calculate the predried value of moisture measurement by the formula:

$$M_P = \frac{m_1' - m_2'}{m_1'} \times 100$$

where

M_P = predried value of the moisture measurement as percentage by mass of the sample,

m_1' = initial mass in grams of the sample, and

m_2' = mass in grams of the sample after predrying.

e) Prepare the test sample for moisture measurement according to **5.**

f) Determine the drying loss of the test sample according to **7**, and calculate the value of moisture content as percentage of mass according to **8.**

g) Calculate the total (as received) moisture content, as percentage by mass, by the formula:

$$Mf = M_P + \frac{100 - M_P}{100} \times Md$$

where

Mf = moisture content (%) of a test sample of corresponding gross sample, and

Md = Additional moisture content (%) obtained according to **8.3** after predrying of the same gross sample.

h) Determine the moisture content, as percentage by mass, of the lot according to **8.4**.

NOTE 1 — The capacity of the weighing device shall be adequate and shall commensurate with the mass of the sample to be weighed and shall have a sensitivity of 0·2% or better of the mass of the sample which is weighed.

NOTE 2 — The drying oven, if used, shall be sufficiently large to accommodate the required number of drying trays.

NOTE 3 — The sample after predrying can be used for determination of the size distribution.

NOTE 4 — An example of calculation of moisture content of a very wet iron ore is given in Table 1.

TABLE 1 EXAMPLE OF CALCULATION OF MOISTURE CONTENT OF A LOT OF VERY WET CALIBRATED IRON ORE

(*Clause* A-1)

PART I

Preliminary drying of the gross sample (before conducting size test)

Lot : Approx 10 000 tonnes
Ore : Calibrated iron ore
Number of sub-lots : 3
(gross samples)

SUB-LOT No.	TONNES (N)	TOTAL MASS BEFORE DRYING	TARE MASS	INITIAL MASS OF SAMPLE	TOTAL MASS AFTER DRYING	LOSS ON DRYING	MOISTURE (%) (M)	$N \times M$ (%)
(1)	(2)	(3)	(4)	(5)=(3)−(4)	(6)	(7)=(3)−(6)	(8)=100×(3)−(6)/(3)−(4)	(9)
		kg	kg	kg	kg	kg		
1	3 000	429·46	76·72	352·74	406·95	22·51	6·381	19 143
2	3 000	438·59	78·48	360·11	416·55	22·04	6·120	18 360
3	3 900	484·00	77·85	406·15	461·15	22·85	5·626	21 941
								59 444

$$M_P = \frac{59\,444}{9\,900} = 6{\cdot}004$$

$$= 6{\cdot}00\ \%$$

PART II

DETERMINATION OF FINAL MOISTURE

SUB-LOT SAMPLE No.	TONNES (*N*)	TOTAL MASS BEFORE DRYING	TARE MASS	INITIAL MASS OF SAMPLE	TOTAL MASS AFTER DRYING	LOSS ON DRYING	MOISTURE	*Md* ADDITIONAL MOISTURE	*Mf* FINAL MOISTURE
(1)	(2)	(3)	(4)	(5)=(3)−(4)	(6)	(7)=(3)−(6)	(8)	(9)	(10)
		g	g	g	g	g	%	%	%
1	3 000	1 085·3 1 033·2	231·5 234·5	853·8 798·7	1 051·2 1 001·5	34·1 31·7	3·99 3·97	3·98	10·11
2	3 000	1 061·5 1 043·8	233·0 232·0	828·5 811·8	1 020·2 1 003·2	41·3 40·6	4·98 5·00	4·99	10·80
3	3 900	1 085·0 1 081·7	230·0 236·0	855·0 845·7	1 055·3 1 051·0	29·7 30·7	3·47 3·63	3·55	8·98

Column 10 is obtained by the formula

$$Mf = M_P + \frac{(100 - M_P)}{100} \times Md$$

The moisture content of the lot is obtained as the weighted average of the sub-lot values, that is,

$$\begin{aligned} Mf \text{ for the lot} &= [(3\,000 \times 10{\cdot}11) + (3\,000 \times 10{\cdot}80) + (3\,900 \times 8{\cdot}98)] \div 9\,900 \\ &= 9{\cdot}873 = 9{\cdot}87\% \end{aligned}$$

APPENDIX B

(*Clause* 3.8)

MOISTURE CORRECTION FOR SPRAYED WATER AND RAIN WATER

B-1. The following formula provides a method of estimating original moisture content of iron ore lot affected by rain or subjected to water spray.

B-1.1 Formula for Rain Water Correction

$$M_0 = M_1 - (100 - M_1) \times \frac{R}{W}$$

where

M_o = original moisture content,
M_1 = average moisture content of rainwater affected cargo,
R = quantity of rain water in tonnes, and
W = quantity of cargo.

NOTE — Quantity (mass) of rain water (rounded to tonnes) shall be calculated from the following formula:

$$R = \frac{A \times m \times d}{1\,000}$$

where

A = effective area in m^2 exposed to rain,
m = amount of rain water in mm for the time duration for which cargo is exposed to rain, and
d = density in tonnes per cubic metre of rain water.

B-1.2 Formula for Sprayed Water Correction

$$M_0 = M_1 - (100 - M_1) \frac{R \times F}{W}$$

where

M_1 = average moisture content of water sprayed cargo,
R = quantity (mass) of sprayed water in tonnes,
F = correction factor as agreed to between the buyer and the seller, and
W = quantity of cargo in tonnes.

NOTE — When water is sprayed into dust emitting iron ores for the purpose of preventing dust pollution, a part of sprayed water disperses in the environment due to various conditions and does not remain wholly in the ore to affect the moisture content. Therefore, the weight of dispersed water should be deducted from the quantity of sprayed water and the ratio of the retained water to sprayed water is denoted by the correction factor F.